

December 1993

Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

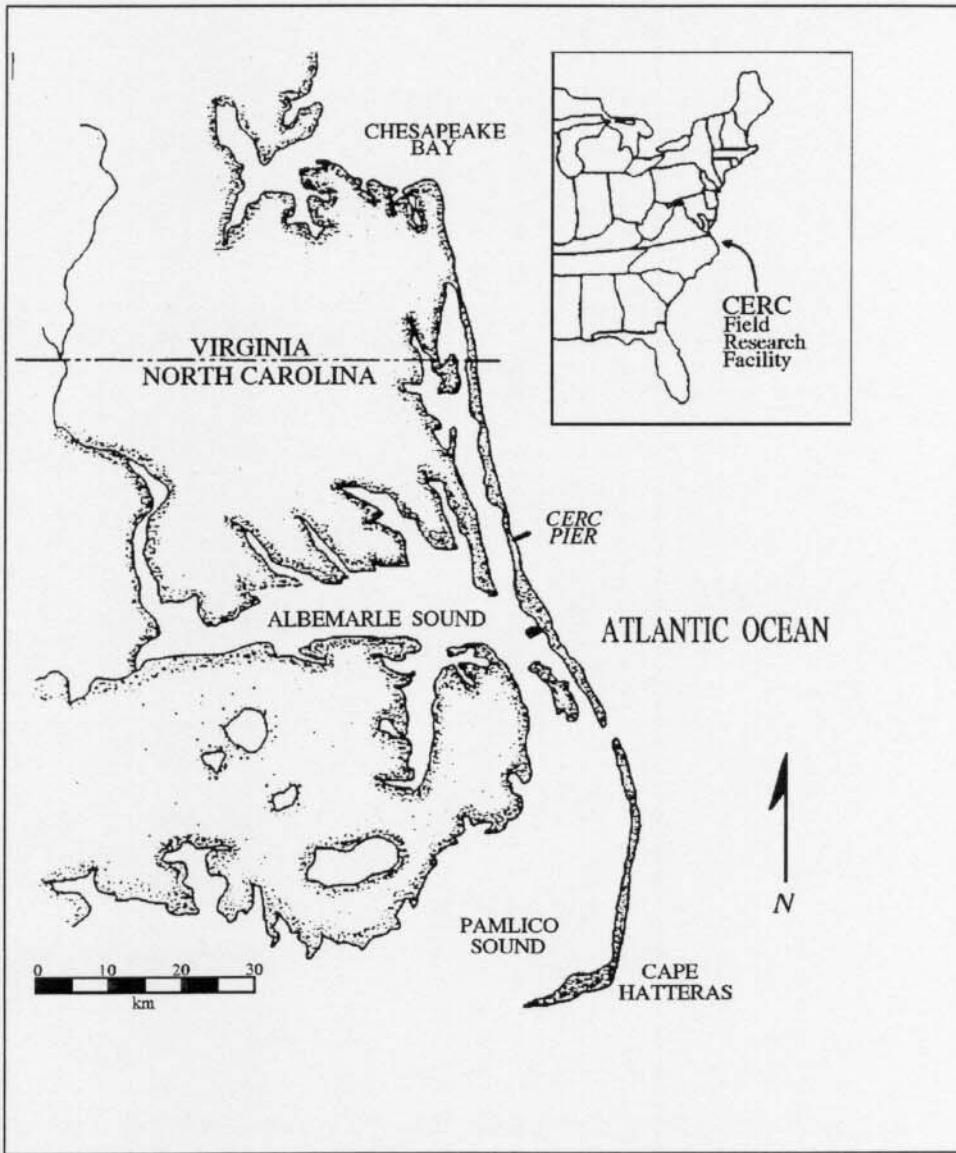


Figure 1. FRF Location Map

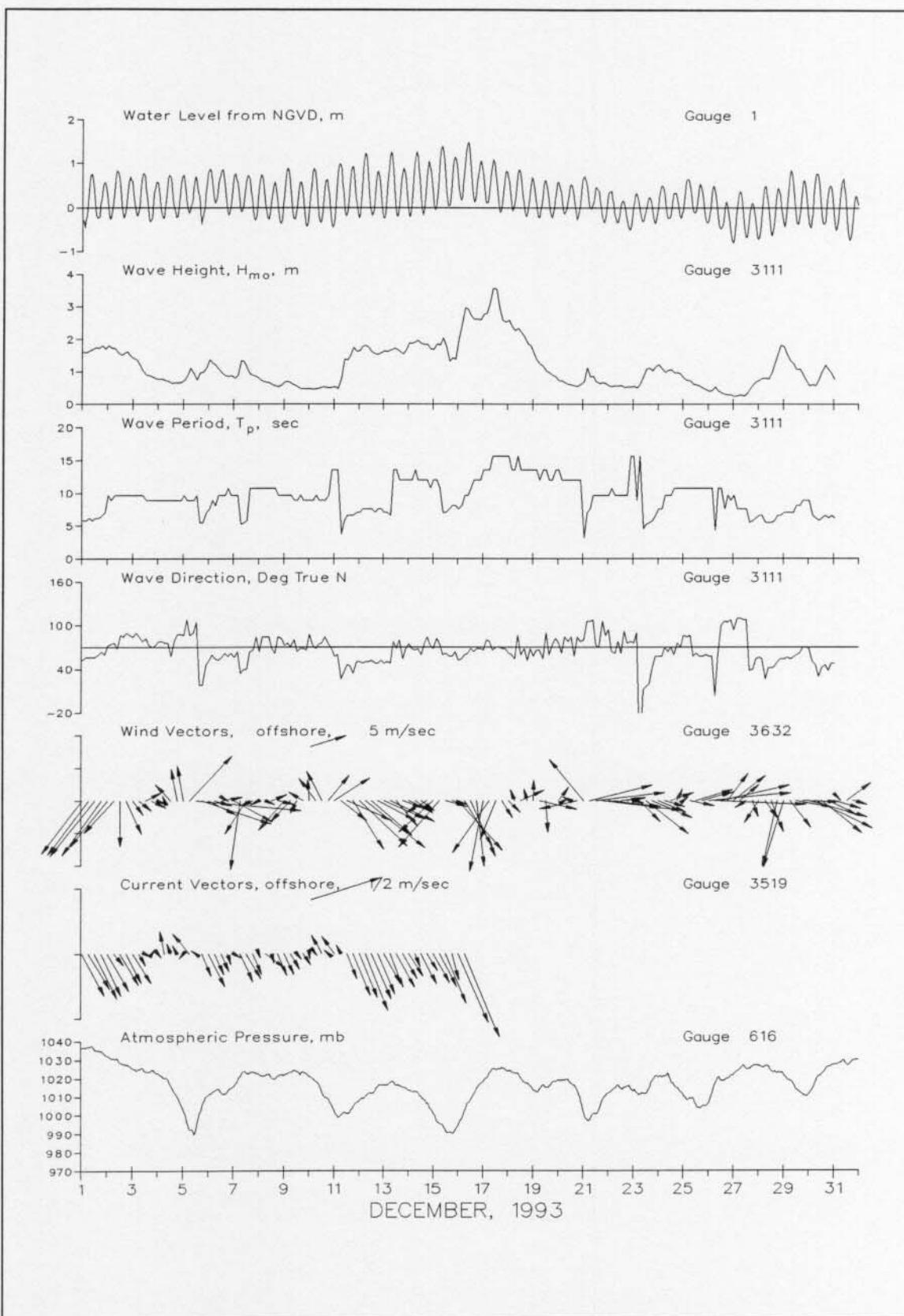


Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

Gauge ID	Description/Remarks		December 1993																														
			Day of the month																														
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0				
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
624	Air Temperature	Gauge Status	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
632	Anemometer on top of building	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
932	Anemometer at seaward end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
641	Pressure Gauge at station 780 on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
625	Baylor staff at station 1860 on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
511	Pressure Gauge 434 m north of FRF pier (0.9 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
519	Current meter 434 m north of FRF pier (0.9 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1	NOAA tide station at seaward end of FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Gauge Status * = Operational / = Partial - = Non-Operational
 Data Collected * = All / = Partial - = None
 Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates X, m Y, m		Gauge Depth NGVD, m	Water Depth NGVD, m
616	Barometer	36 10' 45.48"	75 44' 37.39"	11.60	569.00	-----	-----
632	Building Anemometer	36 10' 45.24"	75 44' 39.53"	21.45	515.83	19.94	-----
932	EOP Anemometer	36 11' 2.64"	75 44' 46.50"	585.20	517.30	19.50	-----
641	780 Pressure	36 10' 51.96"	75 44' 42.21"	239.11	516.64	-1.64	-1.96
625	1860 Baylor	36 11' 2.10"	75 44' 46.31"	568.00	516.64	Surface	-8.36
3111	8m Array	36 11' 15.90"	75 44' 38.88"	914.43	825.52	-7.76	-8.08
511	Pressure N Tripod	36 11' 17.17"	75 44' 34.15"	914.76	950.00	-6.70	-7.90
630	Waverider	36 12' 16.44"	75 47' 19.23"	3934.96	-2400.81	Surface	-17.00
519	Current N tripod	36 11' 17.17"	75 44' 34.15"	914.76	950.00	-5.30	-7.90
1	NOAA Tide	36 11' 2.95"	75 44' 46.76	596.49	514.20	Surface	-7.62

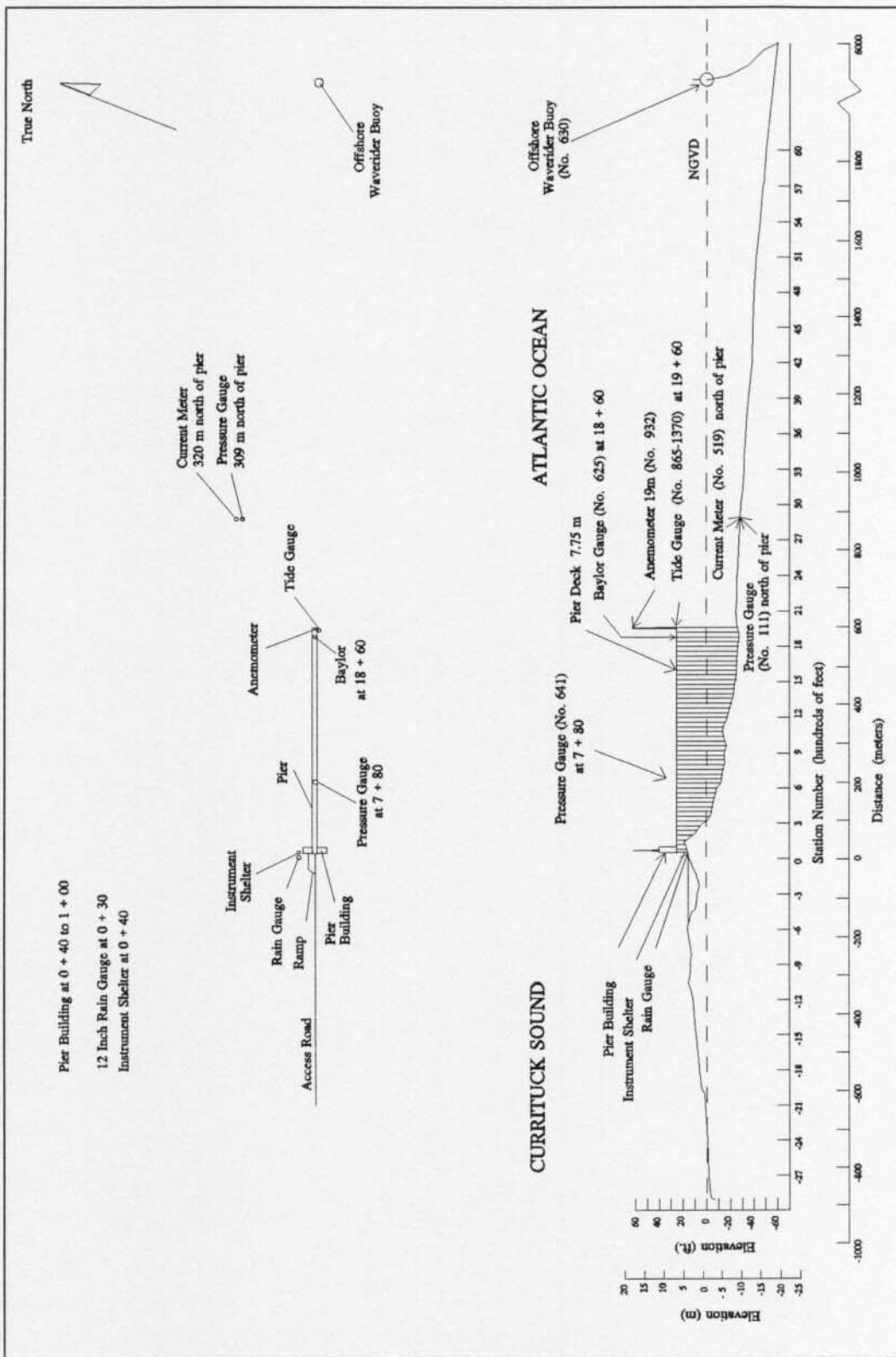


Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 4) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

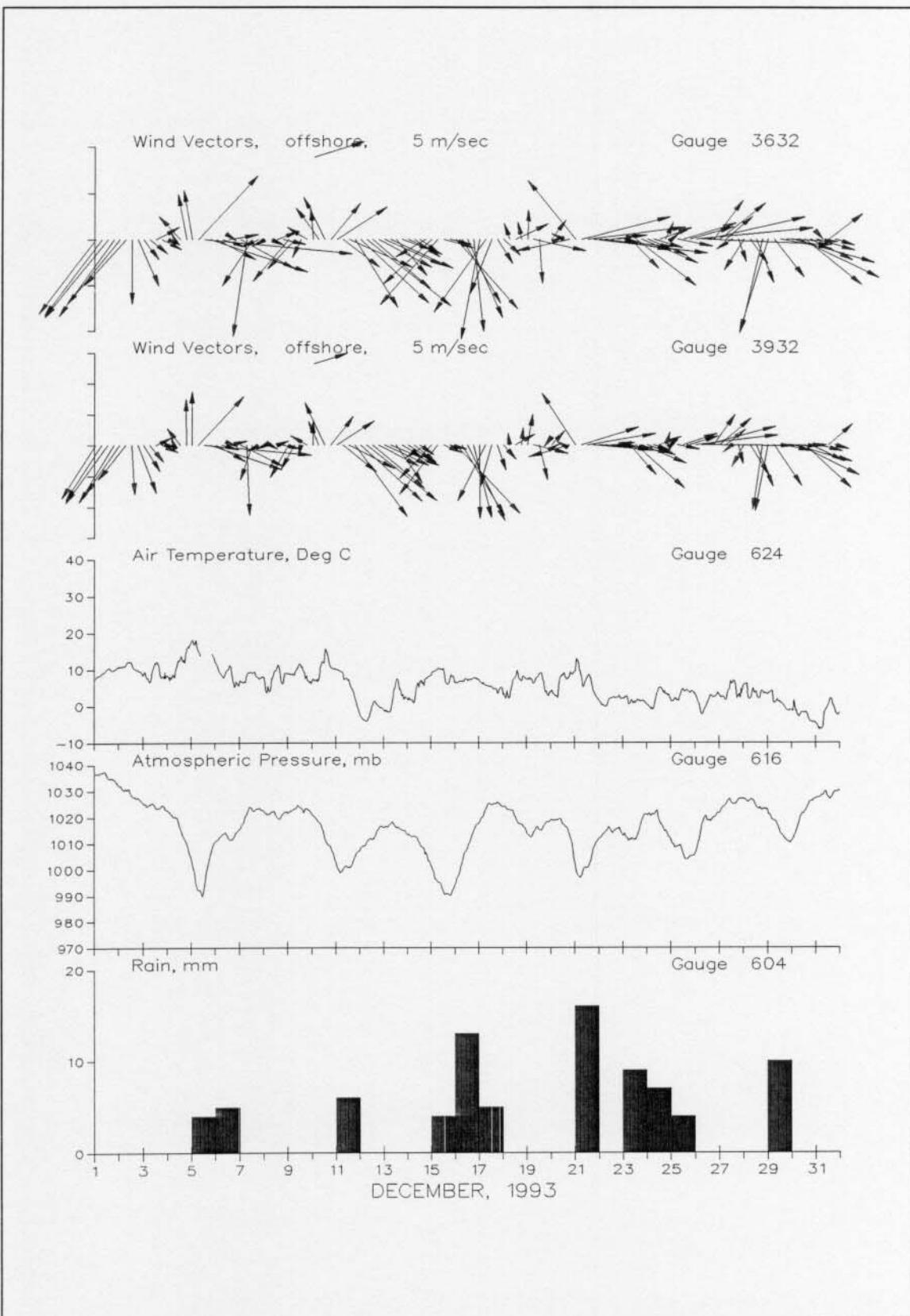


Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

December 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	10	29	7.5	1036.5	0
	700	10	29	8.7	1037.0	0
	1300	11	32	10.3	1035.4	0
	1900	10	27	9.9	1034.8	0
2	100	9	31	10.7	1032.0	0
	700	7	34	11.0	1030.8	0
	1300	8	357	11.8	1028.6	0
	1900	8	341	9.9	1027.5	0
3	100	5	331	8.7	1025.3	0
	700	3	324	6.7	1025.1	0
	1300	3	1	11.6	1023.7	0
	1900	3	297	7.9	1024.6	0
4	100	1	283	8.2	1022.6	0
	700	1	159	7.9	1020.2	0
	1300	3	146	13.0	1015.8	0
	1900	7	179	15.2	1010.2	0
5	100	9	179	18.1	1002.7	0
	700	10	218	15.2	992.3	0
	1300	15	276	Inoperative	992.9	4
	1900	11	291		1005.5	0
6	100	5	302	11.6	1011.1	0
	700	2	288	Inoperative	1013.4	0
	1300	3	255	10.0	1012.1	5
	1900	0		5.3	1012.7	0
7	100	7	299	7.0	1015.8	0
	700	11	357	8.4	1021.1	0
	1300	6	17	8.9	1022.8	0
	1900	2	57	7.8	1023.5	0
8	100	1	59	7.1	1022.2	0
	700	1	304	4.5	1021.7	0
	1300	2	247	10.2	1020.3	0
	1900	3	283	6.0	1021.2	0
9	100	6	26	8.9	1021.7	0
	700	4	26	8.7	1023.3	0
	1300	2	10	11.4	1023.7	0
	1900	3	123	8.5	1023.4	0
10	100	4	179	7.4	1020.9	0
	700	4	158	7.0	1018.3	0
	1300	7	157	13.4	1012.2	0
	1900	6	214	10.7	1008.5	0

Table 3
Meteorological Data (continued)

December 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	7	233	10.0	1001.5	6
	700	6	312	9.2	1000.1	0
	1300	8	300	7.2	1000.8	0
	1900	14	327	2.4	1004.9	0
12	100	13	315	-2.6	1008.1	0
	700	13	311	-4.1	1010.2	0
	1300	10	313	0.2	1011.9	0
	1900	7	300	0.1	1015.5	0
13	100	7	297	-1.3	1016.2	0
	700	8	295	-1.4	1017.6	0
	1300	7	328	7.0	1016.3	0
	1900	4	305	2.8	1015.1	0
14	100	4	305	1.8	1013.3	0
	700	4	312	0.9	1012.8	0
	1300	2	308	6.6	1009.9	0
	1900	4	54	7.5	1006.6	0
15	100	7	40	8.8	1001.0	0
	700	10	34	10.1	995.4	4
	1300	3	295	10.1	991.0	0
	1900	2	285	7.2	990.2	0
16	100	14	320	6.5	995.2	3
	700	13	331	6.7	1002.5	10
	1300	13	336	7.2	1008.5	0
	1900	12	347	7.7	1014.9	0
17	100	12	359	7.0	1018.4	0
	700	10	23	5.7	1023.1	5
	1300	7	13	5.3	1024.9	0
	1900	4	343	3.8	1025.7	0
18	100	3	322	3.1	1023.9	0
	700	2	172	2.6	1022.9	0
	1300	3	236	7.9	1020.0	0
	1900	3	185	7.0	1017.3	0
19	100	5	188	7.5	1013.4	0
	700	5	285	6.3	1014.5	0
	1300	6	348	8.9	1015.2	0
	1900	0		3.8	1017.7	0
20	100	3	218	4.2	1019.0	0
	700	0		2.2	1019.2	0
	1300	1	122	8.9	1017.3	0
	1900	6	71	8.0	1013.3	0

Table 3
Meteorological Data (concluded)

December 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	10	150	9.6	1000.9	6
	700	9	250	8.0	997.6	10
	1300	10	259	8.1	1000.8	0
	1900	11	276	4.2	1008.3	0
22	100	7	273	1.4	1012.0	0
	700	6	277	-0.1	1014.7	0
	1300	3	264	2.3	1014.4	0
	1900	2	254	2.4	1015.6	0
23	100	2	276	2.1	1013.4	0
	700	6	322	0.7	1011.5	6
	1300	10	315	1.1	1011.9	3
	1900	7	295	1.4	1018.9	0
24	100	4	293	0.4	1020.8	0
	700	3	289	-0.5	1021.3	0
	1300	3	246	5.1	1018.5	0
	1900	2	197	3.4	1014.9	7
25	100	1	227	1.3	1010.6	0
	700	3	282	1.7	1009.1	4
	1300	5	248	4.4	1005.4	0
	1900	4	250	3.6	1005.1	0
26	100	12	261	2.8	1006.9	0
	700	13	270	-2.1	1017.1	0
	1300	10	252	1.3	1019.0	0
	1900	6	210	2.5	1020.2	0
27	100	6	225	2.9	1022.0	0
	700	4	227	1.7	1025.0	0
	1300	2	45	6.4	1025.3	0
	1900	3	346	3.1	1026.8	0
28	100	4	26	5.9	1027.0	0
	700	6	331	2.1	1026.7	0
	1300	7	340	4.0	1024.0	0
	1900	11	7	4.2	1023.0	0
29	100	11	9	3.4	1021.8	5
	700	8	329	0.9	1018.8	5
	1300	5	282	1.0	1014.1	0
	1900	5	272	-0.9	1011.3	0
30	100	9	287	-1.2	1011.6	0
	700	10	299	-2.8	1017.9	0
	1300	10	316	-1.6	1022.2	0
	1900	5	298	-4.2	1026.2	0
31	100	4	285	-4.9	1027.6	0
	700	0		-5.9	1028.6	0
	1300	5	224	0.7	1027.6	0
	1900	2	287	-0.8	1029.8	0
		Resultant		Mean	Mean	Total
		4	311	5.3	1016.2	83

3 Wave Data

Wave data are collected from a Baylor staff gauge (Gauge 625), two pressure wave gauges (641 and 511) and a Waverider buoy (Gauge 630) as shown in Table 1 and Figure 3. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

December 1993											
Day	Hour	641		625		1860		511		630	
		Pressure Gauge	Hmo,m	Baylor	Hmo,m	Tp,sec	Waverider	Hmo,m	Tp,sec	Hmo,m	Tp,sec
1	0100	0.50	10.67	1.45	10.67		1.66	10.24	1.65	5.69	
	0700	0.87	10.24	1.40	5.82		1.47	10.24	1.64	5.82	
	1300	0.58	10.67	1.53	6.09		1.66	5.95	1.83	6.40	
	1900	0.81	9.85	1.61	7.11		1.82	5.82	1.93	6.92	
2	0100	0.63	9.48	1.59	6.56		1.78	6.92	1.73	6.92	
	0700	0.97	9.85	1.48	9.48		1.69	9.14	1.75	8.83	
	1300	0.70	9.48	1.25	8.83		1.48	9.14	1.57	8.83	
	1900	0.83	9.14	1.37	9.85		1.67	9.14	1.81	9.85	
3	0100	0.70	9.85	1.27	9.85		1.43	9.48	1.41	9.48	
	0700	0.73	9.14	1.04	9.48		1.30	8.83	1.25	9.14	
	1300	0.51	9.85	0.87	9.14		0.93	9.48	0.99	9.14	
	1900	0.46	9.85	0.71	8.83		0.83	8.53	0.86	8.26	
4	0100	0.48	9.48	0.69	9.14		0.73	9.48	0.85	8.83	
	0700	0.49	9.48	0.67	9.14		0.73	9.48	0.76	8.83	
	1300	0.44	9.48	0.59	9.14		0.61	9.48	0.75	9.48	
	1900	0.47	8.00	0.68	9.14		0.62	9.14	0.73	9.48	
5	0100	0.50	9.85	0.67	9.14		0.74	9.48	0.99	9.14	
	0700	0.73	9.14	1.06	8.83		1.08	8.53	1.34	8.83	
	1300	0.57	9.85	0.65	9.48		0.69	9.14	1.08	9.85	
	1900	0.50	4.74	0.87	5.57		0.97	5.22	1.24	4.83	
6	0100	0.76	6.56	1.05	6.40		1.24	7.53	1.32	6.74	
	0700	0.56	8.83	1.07	8.53		1.20	8.53	1.27	8.26	
	1300	0.51	9.14	0.83	9.48		1.00	9.85	1.04	9.48	
	1900	0.34	10.67	0.77	10.67		0.94	9.48	0.99	9.48	
7	0100	0.36	9.85	0.71	9.48		0.81	10.24	0.90	9.85	
	0700	0.54	4.66	1.20	5.12		1.22	4.57	1.49	5.02	
	1300	0.72	5.57	1.07	5.45		1.14	11.64	1.33	5.02	
	1900	0.37	10.67	0.77	10.24		0.88	10.24	1.00	10.24	
8	0100	0.41	10.24	0.71	10.67		0.78	11.64	0.85	9.85	
	0700	0.28	9.48	0.55	10.24		0.63	10.24	0.67	10.24	
	1300	0.29	10.24	0.53	9.85		0.62	10.24	0.60	10.24	
	1900	0.19	9.48	0.44	10.24		0.55	9.85	0.59	10.67	
9	0100	0.43	3.82	0.66	9.85		0.66	3.82	0.81	9.14	
	0700	0.32	8.83	0.64	4.41		0.65	9.48	0.74	4.27	
	1300	0.28	9.14	0.48	9.14		0.56	8.53	0.58	9.14	
	1900	0.22	9.48	0.44	9.14		0.47	9.14	0.51	9.14	
10	0100	0.31	8.83	0.48	8.83		0.50	9.14	0.51	8.26	
	0700	0.28	8.53	0.42	9.48		0.46	8.53	0.49	9.48	
	1300	0.39	9.85	0.58	9.85		0.51	9.14	0.63	9.48	
	1900	0.30	9.85	0.46	9.85		0.48	9.14	0.55	9.85	

Table 4
Wave Data (continued)

December 1993									
Day	Hour	641		625		511		630	
		Pressure Gauge Hmo,m	Tp,sec	Baylor 1860 Hmo,m	Tp,sec	Pressure Gauge Hmo,m	Tp,sec	Waverider Hmo,m	Tp,sec
11	0100	0.37	4.66	0.51	9.48	0.52	12.80	0.65	4.66
	0700	0.39	8.26	0.50	12.80	0.47	9.48	0.64	12.19
	1300	0.64	5.82	1.18	6.40	1.34	6.56	1.55	6.40
	1900	1.00	5.82	1.41	6.56	1.64	6.74	1.90	6.56
12	0100	0.68	6.56	1.34	7.11	1.57	7.31	1.89	7.11
	0700	1.19	6.74	1.54	7.11	1.76	7.76	2.04	7.53
	1300	0.60	6.40	1.48	7.53	1.69	7.76	1.88	7.11
	1900	0.95	6.40	1.29	6.56	1.44	7.11	1.64	8.00
13	0100	0.61	7.11	1.41	7.11	1.60	7.11	1.77	7.76
	0700	1.08	6.40	1.48	7.11	1.61	6.92	1.94	6.09
	1300	0.59	13.47	1.49	8.53	1.70	12.19	1.77	7.76
	1900	0.95	12.80	1.38	12.19	1.51	11.64	1.64	12.19
14	0100	0.70	15.06	1.65	12.80	1.74	11.64	1.88	11.64
	0700	1.10	13.47	1.65	12.80	1.80	12.80	1.92	11.64
	1300	0.85	13.47	1.71	12.19	1.96	11.13	1.97	11.64
	1900	1.05	12.19	1.60	12.19	1.70	12.19	1.83	11.13
15	0100	0.80	12.80	1.45	12.19	1.53	10.67	1.62	10.67
	0700	1.07	5.57	1.75	5.82	1.83	5.69	1.88	5.69
	1300	0.88	6.92	1.76	7.31	2.01	7.31	2.00	7.31
	1900	1.01	8.26	1.20	7.76	1.35	8.00	1.61	7.76
16	0100	0.87	5.82	1.49	7.31	1.81	7.53	2.01	5.69
	0700	1.34	8.00	2.51	9.14	2.70	9.48	3.09	8.83
	1300	0.97	10.67	2.31	10.24	2.59	8.53	2.84	10.24
	1900	1.04	12.80	2.37	12.80	2.61	12.80	2.81	11.64
17	0100	0.98	13.47	2.38	12.80	2.57	12.19	2.77	12.80
	0700	1.18	15.06	2.59	12.80	3.03	13.47	3.09	13.47
	1300	1.34	17.07	3.05	16.00	3.38	15.06	3.54	15.06
	1900	1.11	16.00	2.31	13.47	2.52	15.06	2.70	15.06
18	0100	1.28	15.06	2.45	14.22	2.58	15.06	2.49	15.06
	0700	1.16	14.22	2.12	13.47	2.03	15.06	2.35	13.47
	1300	1.02	14.22	2.16	15.06	2.16	13.47	2.30	15.06
	1900	0.79	14.22	1.87	14.22	2.05	14.22	1.81	14.22
19	0100	0.80	14.22	1.48	12.80	1.55	13.47	1.56	13.47
	0700	0.56	14.22	1.12	14.22	1.30	13.47	1.12	12.80
	1300	0.42	12.80	0.97	12.80	0.98	12.19	1.01	13.47
	1900	0.33	13.47	0.80	11.64	0.91	12.19	0.88	12.80
20	0100	0.34	12.80	0.70	12.80	0.69	12.19	0.77	12.19
	0700	0.25	12.80	0.64	12.80	0.70	10.67	0.70	12.19
	1300	0.24	12.80	0.53	12.80	0.59	12.19	0.65	11.64
	1900	0.23	13.47	0.57	11.64	0.55	11.13	0.59	11.13

Table 4
Wave Data (concluded)

December 1993											
Day	Hour	641		625		511		630		Waverider	
		Pressure	Gauge	Baylor	1860	Pressure	Gauge	Hmo,m	Tp,sec		
21	0100	0.37	3.16	0.67	12.80	0.57	11.13	0.73	10.67		
	0700	0.60	7.53	0.89	7.76	0.94	8.00	1.12	7.53		
	1300	0.45	9.14	0.65	9.48	0.74	9.48	0.88	9.14		
	1900	0.35	3.88	0.61	9.85	0.63	9.85	0.82	9.85		
22	0100	0.33	4.27	0.54	9.48	0.58	9.48	0.80	10.67		
	0700	0.21	19.69	0.51	9.85	0.51	10.67	0.63	10.24		
	1300	0.27	18.29	0.57	9.85	0.55	9.85	0.62	9.48		
	1900	0.20	17.07	0.48	9.14	0.50	17.07	0.54	10.24		
23	0100	0.22	17.07	0.48	8.53	0.54	16.00	0.55	16.00		
	0700	0.19	17.07	0.53	17.07	0.53	16.00	0.64	9.14		
	1300	0.70	5.12	0.91	5.22	1.02	5.12	1.36	5.12		
	1900	0.47	5.57	0.95	5.82	0.98	5.69	1.17	6.40		
24	0100	0.55	5.22	1.22	7.11	1.22	7.31	1.26	7.31		
	0700	0.39	3.94	0.94	6.74	1.10	9.85	1.07	6.92		
	1300	0.44	11.13	0.91	10.67	1.04	9.48	1.08	9.85		
	1900	0.29	11.64	0.83	11.13	0.91	10.67	0.93	11.13		
25	0100	0.26	11.64	0.71	11.13	0.81	11.13	0.74	11.13		
	0700	0.20	11.64	0.56	11.13	0.74	10.67	0.70	10.24		
	1300	0.15	10.67	0.48	10.67	0.58	9.85	0.53	10.24		
	1900	0.16	9.85	0.42	10.67	0.52	10.24	0.53	10.24		
26	0100	0.16	7.53	0.36	11.13	0.41	11.13	0.66	10.67		
	0700	0.36	4.74	0.50	4.57	0.52	3.37	0.94	4.66		
	1300	0.17	3.82	0.30	11.13	0.35	7.31	0.60	7.11		
	1900	0.15	4.83	0.27	10.24	0.27	10.67	0.32	6.74		
27	0100	0.14	4.34	0.25	11.13	0.25	5.45	0.30	5.45		
	0700	0.19	7.76	0.27	7.53	0.28	7.53	0.35	7.31		
	1300	0.11	5.95	0.25	7.53	0.27	7.53	0.29	7.53		
	1900	0.25	4.57	0.53	5.45	0.54	5.45	0.62	5.33		
28	0100	0.35	4.13	0.74	5.57	0.73	6.74	0.86	5.45		
	0700	0.44	5.45	0.77	5.57	0.79	5.69	0.96	5.45		
	1300	0.38	5.02	0.80	5.82	0.78	5.12	0.96	5.45		
	1900	0.86	6.24	1.28	6.40	1.44	6.40	1.74	6.09		
29	0100	0.66	7.11	1.65	7.11	1.85	6.74	1.83	7.11		
	0700	0.96	6.40	1.30	6.56	1.33	7.11	1.46	7.31		
	1300	0.59	5.95	1.02	8.00	1.03	6.56	1.27	8.53		
	1900	0.50	5.45	0.94	8.26	0.89	8.00	1.06	8.00		
30	0100	0.21	4.06	0.52	7.53	0.56	9.14	0.69	6.74		
	0700	0.41	6.09	0.57	6.24	0.53	6.24	0.79	5.82		
	1300	0.63	4.34	0.89	5.95	0.90	6.09	1.14	5.95		
	1900	0.86	6.24	1.05	6.56	1.12	6.40	1.20	6.74		
31	0100	0.50	5.22	0.76	6.09	0.85	6.56	0.90	6.40		
	0700	0.37	4.49	0.62	6.40	0.67	5.95	0.76	5.82		
	1300	0.17	5.02	0.48	7.31	0.48	7.31	0.55	7.53		
	1900	0.15	9.85	0.38	9.14	0.42	9.14	0.44	9.85		
		Mean	0.56	9.20	1.03	9.31	1.12	9.37	1.24	8.98	
		Std dev	0.31	3.70	0.58	2.64	0.65	2.73	0.67	2.64	

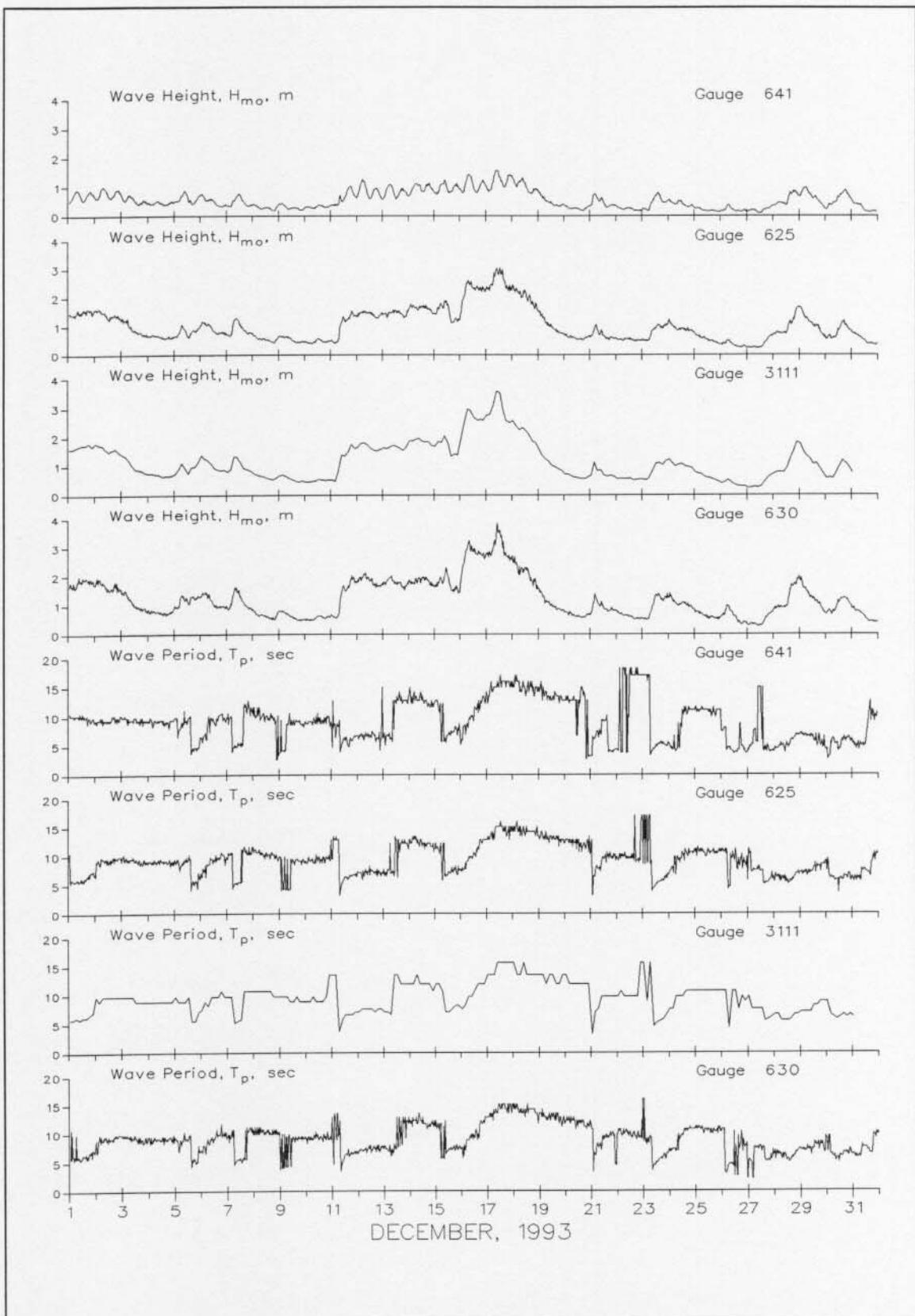


Figure 5. Time History of Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or off-shore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

Notice: The current meter data
(gauges 519, 529, 3511, 3519)
was fouled by marine growth from
01 DEC - 16 DEC at which time the
gauge failed. Please call us if
you must use this data.

Table 5
Current Meter Data - Gauge 519

December 1993																		
	Cross Long				Cross Long				Cross Long									
	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	8	35	35	156			1300	3	21	21	161	22	100				
	700	8	29	31	153			1900	5	35	35	160		700				
	1300	7	37	38	157		12	100	5	36	37	160		1300				
	1900	6	35	35	158			700	5	46	47	161		1900				
2	100	8	31	32	154			1300	6	37	38	159	23	100				
	700	5	10	11	144			1900	5	33	33	160		700				
	1300	7	26	27	154		13	100	6	25	26	155		1300				
	1900	5	24	25	157			700	3	27	28	161		1900				
3	100	7	25	26	152			1300	7	28	29	155	24	100				
	700	2	10	10	156			1900	6	21	22	153		700				
	1300	4	3	5	120		14	100	6	20	20	151		1300				
	1900	3	-2	4	32			700	1	11	11	160		1900				
4	100	1	3	4	146			1300	5	25	26	156	25	100	Gauge			
	700	1	-16	17	350			1900	4	15	15	153		700				
	1300	0	-7	8	343		15	100	6	24	25	155		1300				
	1900	0	-6	7	337			700	6	27	28	156		1900				
5	100	-2	3	5	214			1300	5	41	41	161	26	100				
	700	-7	-16	19	324			1900	0	21	21	168		700				
	1300	-2	-2	4	309		16	100	8	56	57	160		1300				
	1900	2	18	18	162			700	9	68	68	160		1900				
6	100	5	27	28	157			1300					27	100				
	700	3	17	17	159			1900						700				
	1300	2	15	15	159		17	100						1300	Inoperative			
	1900	1	9	9	163			700						1900				
7	100	4	4	6	125			1300					28	100				
	700	4	23	23	159			1900						700				
	1300	5	21	22	154		18	100						1300				
	1900	3	17	17	159			700						1900				
8	100	0	4	4	161			1300		Gauge			29	100				
	700	11	14	18	131			1900						700				
	1300	0	8	8	167		19	100						1300				
	1900	2	18	18	161			700						1900				
9	100	3	17	17	159			1300					30	100				
	700	3	13	14	153			1900						700				
	1300	2	5	6	146		20	100	Inoperative						1300			
	1900	3	10	10	150			700						1900				
10	100	0	4	4	174			1300					31	100				
	700	1	2	2	144			1900						700				
	1300	-3	-14	15	334		21	100						1300				
	1900	-1	-2	4	316			700						1900				
11	100	-5	-13	15	327			1300						1900				
	700	-1	-6	7	335			1900										

KEY:

+crossshore = offshore, cm/sec
 -crossshore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

December 1993

Day	Pier End				Mid-Surf Zone				Beach		
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	-10	34	35	177	-11	36	37	177	North	38	S
2	-15	25	30	191	-3	10	11	177	North	3	S
3	-6	7	9	202	-10	-32	33	323	South	37	N
4	0	-21	21	340	20	-16	25	31	South	3	N
5	26	-44	51	11	34	-38	51	22	South	71	N
6	0	15	15	160	0	76	76	160	North	59	S
7	0	28	28	160	0	61	61	160	North	57	S
8	0	36	36	160	0	-15	15	340	South	30	N
9	0	16	16	160	0	36	36	160	North	20	S
10	0	-16	16	340	0	-16	16	340	South	20	N
11	0	25	25	160	0	55	55	160	North	51	S
12	0	102	102	160	0	122	122	160	North	102	S
13	13	44	45	143	0	87	87	160	North	102	S
14	0	32	32	160	0	68	68	160	North	41	S
15	0	29	29	160	-47	47	66	205	North	76	S
16	0	87	87	160	0	152	152	160	North	91	S
17	0	87	87	160	0	122	122	160	North	76	S
18	0	0	0		20	16	26	70	South	36	N
19	17	17	25	70	35	-28	44	31	South	10	N
20	0	-7	7	340	0	-44	44	340	South	15	N
21	20	20	29	70	16	-20	26	19	South	15	N
22	8	-8	11	25	0	-38	38	340	South	5	N
23	0	13	13	160	0	34	34	160	North	13	S
24	0	16	16	160	10	13	16	70	North	0	
25	0	36	36	160	17	-29	34	11	South	8	N
26	0	23	23	160	0	19	19	160	North	20	S
27	5	-7	9	17	5	-10	11	7	South	4	N
28	0	51	51	160	8	38	39	149	North	19	S
29	-10	51	52	171	-6	55	56	166	North	36	S
30	14	55	57	146	15	61	63	146	North	26	S
31	19	-38	43	7	10	10	14	70	South	12	S

KEY:

- +crossshore = offshore, cm/sec
- crossshore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics			
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m	
1	0710	45			108	12.5	1.0247	0.9	
2	0745	45			119	11.9	1.0230	0.9	
3	0735	80			15	11.9	1.0220	1.2	
4	0920	60			9	12.2	1.0218	1.5	
5	0918	90			15	14.2	1.0254	0.6	
6	0725	55		Gauge	122	13.1	1.0253	0.6	
7	0825	30			116	12.5	1.0250	0.6	
8	0715	60			14	11.9	1.0240	0.9	
9	0722	50		inoperative	11	11.4	1.0240	1.2	
10	0745	90		140	15	11.4	1.0240	0.9	
11	0815	40			21	13.1	1.0254	0.6	
12	0800	40		most of	110	8.3	1.0254	0.6	
13	0730	40			122	9.2	1.0244	0.6	
14	0800	45			116	8.6	1.0222	0.6	
15	0730	40		20	month	98	9.7	1.0220	0.6
16	0745	50			262	10.0	1.0241	0.6	
17	0730	60			381	9.2	1.0240	0.6	
18	0800	50			241	8.6	1.0240	0.6	
19	0830	50			85	9.7	1.0252	0.6	
20	0715	50		80	12	9.7	1.0249	1.2	
21	0715	95			64	10.6	1.0250	0.9	
22	0730	60			3	7.8	1.0260	0.6	
23	0730	30			21	8.9	1.0254	1.5	
24	0845	50			76	8.6	1.0259	1.2	
25	0900	55			12	6.9	1.0240	0.9	
26	0745	20			3	7.8	1.0246	0.6	
27	0745	120			12	8.3	1.0258	1.2	
28	0800	65		30	30	8.3	1.0252	0.9	
29	0900	25			171	6.7	1.0214	1.8	
30	0930	5			17	6.7	1.0231	1.2	
31	1030	25			24	5.8	1.0230	1.5	

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

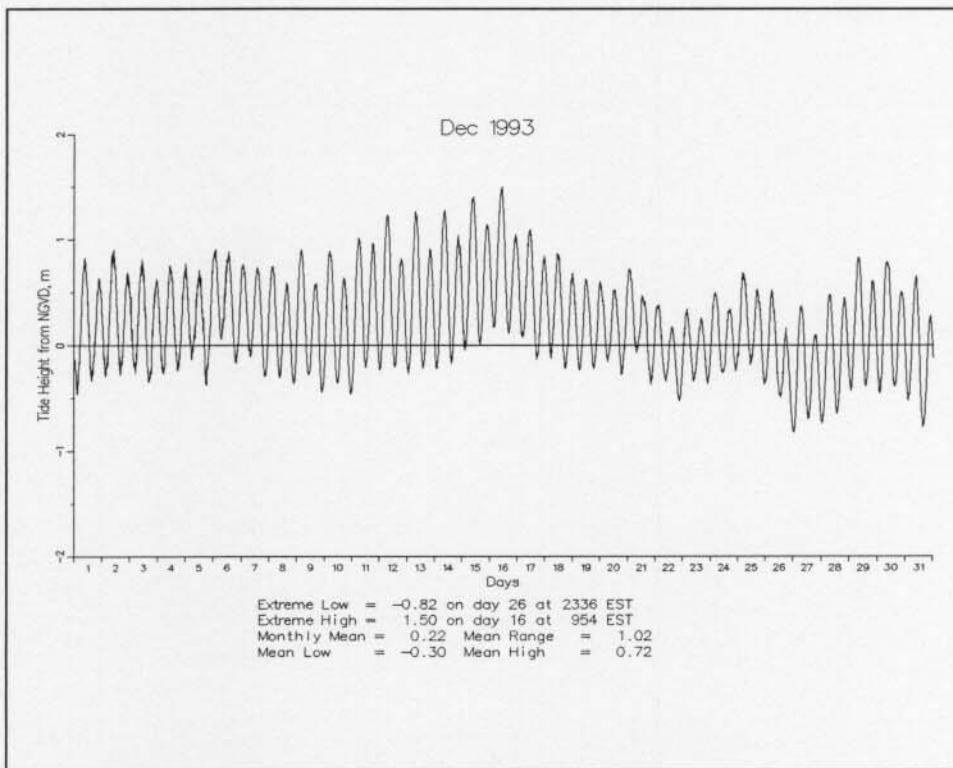


Figure 6. Water Level Time History

Table 8
Water Levels, m NGVD

December 93															
High			Low			Mean	Range	High			Low			Mean	Range
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	m
1	0836	0.83	1	0148	-0.47	0.21	1.29	16	2200	1.05	16	1542	0.11	0.61	0.94
1	2030	0.63	1	1430	-0.34	0.15	0.97	17	1030	1.10	17	0406	0.08	0.57	1.02
2	0924	0.90	2	0230	-0.29	0.31	1.19	17	2236	0.84	17	1618	-0.14	0.37	0.98
2	2100	0.69	2	1512	-0.28	0.22	0.97	18	1006	0.87	18	0436	-0.13	0.39	1.00
3	0942	0.81	3	0430	-0.26	0.27	1.08	18	2324	0.68	18	1636	-0.22	0.22	0.90
3	2224	0.63	3	1542	-0.35	0.14	0.98	19	1054	0.63	19	0524	-0.24	0.19	0.87
4	0948	0.76	4	0412	-0.27	0.25	1.02	19	2318	0.61	19	1800	-0.22	0.19	0.83
4	2336	0.77	4	1636	-0.24	0.25	1.01	20	1206	0.52	20	0612	-0.16	0.19	0.68
5	1100	0.71	5	0436	-0.13	0.27	0.84	21	0054	0.72	20	1812	-0.28	0.24	1.00
6	0118	0.90	5	1742	-0.38	0.33	1.28	21	1212	0.47	21	0730	-0.07	0.20	0.54
6	1230	0.89	6	0624	0.06	0.46	0.83	22	0236	0.38	21	1942	-0.37	0.04	0.76
7	0048	0.77	6	1900	-0.17	0.31	0.93	22	1412	0.17	22	0854	-0.34	-0.09	0.52
7	1312	0.73	7	0712	-0.11	0.32	0.84	23	0318	0.34	22	2030	-0.53	-0.09	0.87
8	0142	0.74	7	1942	-0.30	0.23	1.04	23	1524	0.26	23	0836	-0.34	-0.04	0.60
8	1442	0.59	8	0830	-0.31	0.14	0.90	24	0400	0.50	23	2106	-0.37	0.10	0.86
9	0306	0.90	8	2030	-0.36	0.29	1.26	24	1654	0.34	24	1006	-0.26	0.04	0.60
9	1612	0.59	9	0936	-0.28	0.16	0.87	25	0342	0.69	24	2136	-0.25	0.22	0.94
10	0348	0.89	9	2130	-0.45	0.24	1.34	25	1612	0.53	25	1024	-0.19	0.17	0.72
10	1630	0.64	10	1054	-0.35	0.13	0.99	26	0448	0.52	25	2230	-0.37	0.05	0.90
11	0518	1.01	10	2212	-0.46	0.28	1.48	26	1712	0.16	26	1236	-0.49	-0.22	0.65
11	1730	0.96	11	1124	-0.21	0.37	1.17	27	0636	0.37	26	2336	-0.82	-0.21	1.20
12	0600	1.23	11	2330	-0.23	0.50	1.46	27	1806	0.10	27	1212	-0.70	-0.28	0.80
12	1800	0.82	12	1248	-0.21	0.33	1.03	28	0654	0.48	28	0012	-0.74	-0.12	1.23
13	0700	1.26	13	0036	-0.27	0.48	1.53	28	1936	0.45	28	1248	-0.65	-0.09	1.11
13	1906	0.91	13	1312	-0.22	0.36	1.13	29	0700	0.84	29	0100	-0.43	0.23	1.27
14	0806	1.28	14	0054	-0.23	0.53	1.51	29	1924	0.61	29	1312	-0.38	0.11	0.99
14	2000	1.05	14	1406	-0.17	0.45	1.22	30	0718	0.79	30	0112	-0.45	0.22	1.25
15	0918	1.41	15	0200	-0.05	0.69	1.46	30	1954	0.51	30	1436	-0.39	0.06	0.90
15	2100	1.14	15	1436	0.01	0.60	1.13	31	0900	0.66	31	0206	-0.52	0.05	1.18
16	0954	1.50	16	0254	0.17	0.84	1.33	31	2124	0.28	31	1448	-0.77	-0.25	1.05

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in November 1993 and the survey(s) in December 1993 on profile line 188, located 517 m south of the pier.

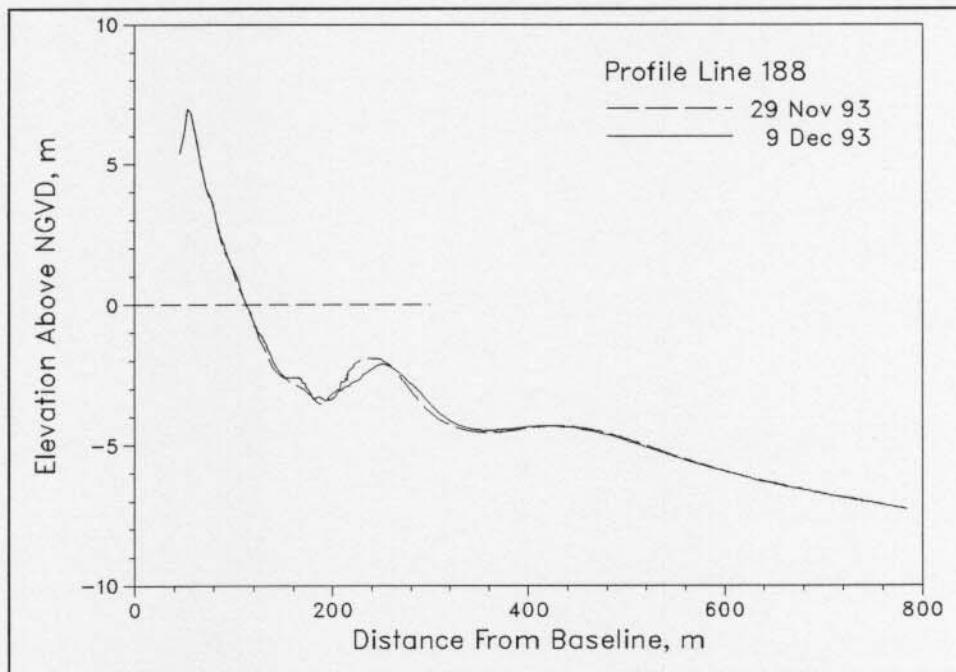


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in December.

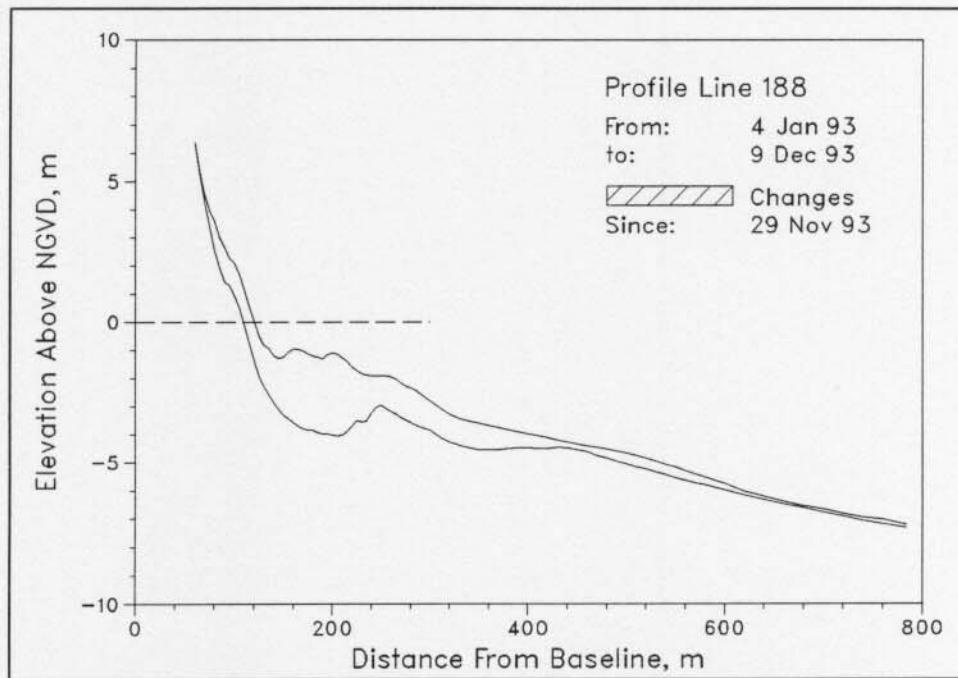


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 8 December. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

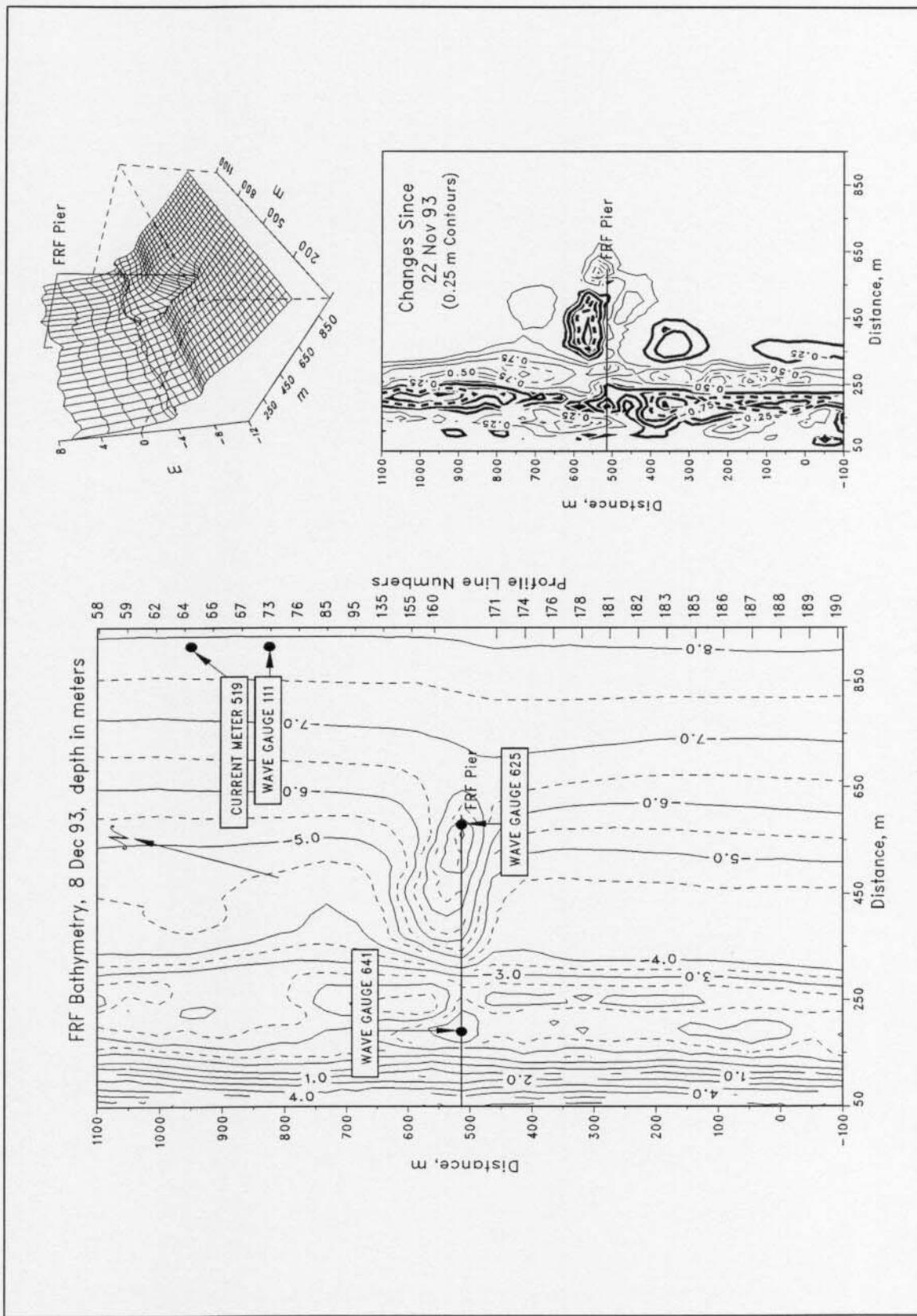


Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m.

<u>Start</u>	<u>End</u>
16 Dec (0400)	18 Dec (1408)

B. Storm Synopsis.

Northeasterly winds were funneled between a Canadian high pressure system and a low pressure system over Cape Hatteras. Winds intensified as the low pressure system moved along the North Carolina coast and began moving out to sea by the morning of 16 December. Maximum onshore winds reached 10 m/s at 0508 EST on 17 December. The maximum H_{mo} , at gauge 630, reached 3.85 m ($T_p=15.1$ s) at 1034 on 17 December. There was 6 mm of precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge
USACE-OCE
USACE-SAD
USACE-NAP
USACE-SAW
USACE-WES
NAVSAC
NOAA/NOS/OMS
National Marine Fisheries

U.S. Geological Survey
U.S. Library of Congress
U.S. National Park Service
U.S. National Weather Service
U.S. Naval Academy
U.S. Naval Civil Eng. Lab
U.S. Naval Oceanographic Off.
U.S. Naval Research Lab

Colleges/Universities:

Bucknell University
California Inst. of Tech.
Duke Marine Lab
East Carolina University
Florida Inst. of Tech.
M.I.T.
Naval Post Graduate School
NC State University
Old Dominion University
Oregon State University
Prince George's College

Scripps Institution of Oceanography
Stockton State College
University Calif-Berkeley
University of Florida
University of Maryland-College Park
University of Maryland-Baltimore
University of North Carolina
University of N C-Seagrant Program
University of Virginia
Va. Inst. of Marine Science
Rutgers University

Others:

Allied Signal Aerospace Co.
Applied Physics Lab
Cape Hatteras Nat. Seashore
Coastal and Est. Res., Inc.
Coastal Science & Eng., Inc.
Dr. Cy Galvin
GEOMET Tech., Inc.
Mr. Hodges
Dr. Hylton
Mr. Mason
Mr. Rodgers

WCTI-TV
MEC Systems Corporation
Moffatt & Nichol, Eng.
N.C. Div. Coastal Management
Oregon Inlet & Waterways Commis.
Raleigh-Durham Airport
Mr. Rowland
Mr. Savage
Science Application Int'l. Corp
Sherwood Industries
SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)